REMARKS

On the basis of claims 1-42, reconsideration of this application is requested. Claims 1-42 as originally submitted are fully supported by the specification as filed, and as established by the following remarks.

The Examiner suggests that claims 1-42 are functional, vague, and indefinite, and fail to recite any means plus function. Respectfully, however, claims 1-42 are **not** intended to be means plus function claims. Moreover, the claims are definite and have the necessary structural elements or steps which are positively recited as apparatus and method claims as the case may be. Thus, claims 1-42 are not functional, vague, and indefinite.

The Examiner suggests that claims 1-42 are vague and indefinite, and fail to recite any means plus function. However, claims 1-42 are **not** intended to be in a means plus function format. Moreover, the claims, as defined, are structural elements which are positively recited as apparatus claims. Thus, claims 1-42 are not vague and indefinite.

Independent claims 1 and 12 are rejected under 35 U.S.C 102(b) as being anticipated by Sugiyama *et al.* (US. 5,392,307), hereinafter referred to as the *'307* patent; and, independent claims 17 and 31 are rejected under 35 U.S.C 103(a) as being unpatentable over Sugiyama *et al.* (US. 5,392,307) in view of Jayaraman *et al.* (WO 98/07218).

Clearly, the *'307* patent teaches a VCSEL structure having DBRs made from alternating layers of AlGaAsSb and InAlAs, thereby. However, **nowhere** does the *'307* patent teach a VCSEL structure having DBRs made from layers of **InP** and AlGaAsSb. By using InP in the DBRs, the Applicants' have clearly demonstrated a significant reduction of the conduction band offset (pp. 12, paragraph 56, FIG. 12). Moreover, by using InP as in the present DBRs, the Applicants' have also demonstrated far better thermal properties for the DBR (e.g., FIG. 14) as compared to the InAlAs or InGaAlAs materials of the *'307* patent.

Furthermore, including InP in the DBR layer, permits the DBR to be substantially lattice matched to an InP substrate (for e.g., as claimed in newly added claim 28). Conventional VCSELs are based on a substrate of gallium arsenide (GaAs) and operate at short wavelengths (around 0.85μm). One key problem that arises from using short wavelength VCSELs for transmitting light through a fiber optic cable is dispersion. In other words the information is blurred if it is transmitted at a high data rate and propagates a long distance. Thus, VCSELs that emit at longer wavelengths **reduce the blurring problem**. But unless very exotic active regions are used, they require a different substrate, namely **InP**, as claimed by the present invention.

Accordingly, claims 1, 12, 17, and 31 have been amended to include the feature of a DBR having the compound of **indium phosphide (InP)** in addition to antimony (Sb) in at least one layer.

Accordingly, it is requested that the rejections applied be traversed.

New claims 43-46 are added to further distinguish the invention from the prior art.

Thus, in view of the above, it is submitted that this application is now in good order for allowance, and such early action is respectfully solicited. Should matters remain which the Examiner believes could be resolved in a telephone interview, the Examiner is requested to telephone the Applicants' undersigned attorney.

Respectfully submitted,

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VERSION TO SHOW CHANGES

IN THE SPECIFICATION

Please replace paragraph 44, pages 9-10, with the following paragraph:

[0044] FIG. 7 is a schematic representation of another aspect of the present invention, in which an electrically-pumped, Sb-based vertical-cavity laser 30 operating at 1.55 μm is produced in a single epitaxial growth. The laser 30 employs AlGaAsSb DBRs 32 and 34 and an AlInGaAs-based active region 36, and has a room temperature threshold current density of 1.4 kA/cm^2 and an external quantum efficiency of 18%. The DBRs 28 and 30 employ a plurality of layers of semiconductor material, each alternating [layer having the material composition of AlGaAsSb. In another embodiment, the DBRs 28 and 30 have a plurality of layers of semiconductor material, only one of which includes the element antimony (Sb).] layer having the material composition of AlGaAsSb. In another embodiment, the DBRs 32 [28] and 34 [30] have a plurality of layers of semiconductor material, only one of which includes the element antimony (Sb).

IN THE CLAIMS

Please amend claims 1, 12, 17, and 31.

1. (Amended) A distributed Bragg reflector for use in a vertical cavity surface emitting laser, comprising a plurality of layers of semiconductor material doped to reduce voltage drop and optical loss in a vertical cavity surface emitting laser, the plurality of layers including at least one layer having the element antimony (Sb), and at least one layer being substantially composed of an indium phosphide (InP) compound, wherein the plurality of layers of semiconductor material also including the elements arsenic, aluminum, and gallium.

2. The distributed Bragg reflector of claim 1, wherein the plurality of layers of semiconductor material are epitaxially grown on a substrate.

3. The distributed Bragg reflector of claim 2, wherein the substrate includes indium phosphide (InP).

4. The distributed Bragg reflector of claim 2, wherein the plurality of layers are comprised of alternating layer pairs of $Al_aGa_{1-a}As_bSb_{1-b}$ which are approximately lattice-matched to InP, and where "a" and 1b" indicate relative proportions of atoms.

5. The distributed Bragg reflector of claim 4, wherein "a" is greater than 0.9 in one layer of the alternating layer pairs and less than 0.9 in another layer of the alternating layer pairs.

6. The distributed Bragg reflector of claim 4, wherein "a" is less than 0.3 in one layer of the alternating layer pairs and greater than 0.3 in another layer of the alternating layer pairs.

7. The distributed Bragg reflector of claim 4, wherein "a" is less than 0.3 in one layer of the alternating layer pairs and greater than 0.9 in another layer of the alternating layer pairs.

8. The distributed Bragg reflector of claim 4, wherein "a" is less than 0.3 in one layer of the alternating layer pairs and "a" is large enough such that the layer is substantially transparent to lasing light.

9. The distributed Bragg reflector of claim 2, wherein the substrate is n-doped with the element selenium (Se).

10. The distributed Bragg reflector of claim 1, wherein the plurality of layers of semiconductor material are configured to form a reflective device.

11. The distributed Bragg reflector of claim 10, wherein the reflective device is n-doped using tellurium.

12. (Amended) A device for reflecting light to an active region in a vertical cavity surface emitting laser, comprising:

a mirror portion including the element antimony (Sb) <u>and an indium phosphide (InP) compound</u> epitaxially grown on a substrate, the mirror portion including a plurality of layers of semiconductor material, wherein electric current is pumped through the plurality of layers forming the mirror portion to electrically pump the active region.

13. The device of claim 12, wherein the substrate includes indium phosphide (InP).

14. The device of claim 13, wherein the substrate is n-doped with the element selenium (Se).

15. The device of claim 12, wherein the mirror portion is n-doped to reduce voltage drop and optical loss in a vertical cavity surface emitting laser.

16. The device of claim 15, wherein the mirror portion is n-doped using tellurium.

17. (Amended) A vertical cavity surface emitting laser, comprising:

a pair of mirror portions [including the element antimony (Sb)] epitaxially grown on a substrate, the pair of mirror portions including a plurality of layered stacks of paired semiconductor material, wherein the pair of mirror portions are n-doped to reduce voltage drop and optical loss;

<u>wherein each of the pair of mirror portions includes at least one of the element antimony (Sb) and the compound indium phosphide (InP);</u>

an active region epitaxially grown on the substrate and positioned between the pair of mirror portions;

a doped tunnel junction configured to provide electron-hole conversion from one of the pair of mirror portions; and

wherein the pair of mirror portions, the active region, and the tunnel junction are epitaxially grown on the substrate in a single step, and wherein electric current is pumped through the pair of mirror portions to electrically pump the active region.

18. The vertical cavity surface emitting laser of claim 17, wherein the substrate includes indium phosphide (InP).

19. The distributed Bragg reflector of claim 17, wherein the plurality of layers are comprised of alternating layer pairs of $Al_aGa_{1-a}As_bSb_{1-b}$ which are approximately lattice-matched to InP, where "a" and "b" indicate relative proportions of the atoms.

20. The distributed Bragg reflector of claim 19, wherein "a" is greater than 0.9 in one layer of the alternating layer pairs and less than 0.9 in another layer of the alternating layer pairs.

21. The distributed Bragg reflector of claim 19, wherein "a" is less than 0.3 in one layer of the alternating layer pairs and greater than 0.3 in another layer of the alternating layer pairs.

22. The distributed Bragg reflector of claim 19, wherein "a" is less than 0.3 in one layer of the alternating layer pairs and greater than 0.9 in another layer of the alternating layer pairs.

23 The distributed Bragg reflector of claim 19, wherein "a" is less than 0.3 in one layer of the alternating layer pairs and "a" is large enough such that the layer is substantially transparent to lasing light.

24. The vertical cavity surface emitting laser of claim 17, wherein the substrate is n-doped with the element selenium (Se).

25. The vertical cavity surface emitting laser of claim 17, wherein the doped tunnel junction is n-doped with silicon (Si).

26. The vertical cavity surface emitting laser of claim 17, wherein the doped tunnel junction is p-doped with CBr4.

27. The vertical cavity surface emitting laser of claim 17, wherein the pair of mirror portions include a first mirror portion positioned on a top of the active region and a second mirror portion positioned below the active region.

28. The vertical cavity surface emitting laser of claim 27, wherein the first and second mirror portions are n-doped using tellurium.

29. The vertical cavity surface emitting laser of claim 17, wherein the active region is grown to include a cavity having five strain compensated quantum wells, the quantum wells including the elements aluminum, indium, gallium, and arsenic.

30. The vertical cavity surface emitting laser of claim 17, wherein the VCSEL operates in the approximate range from between 1.3 microns and 1.6 microns.

31. (Amended) A vertical cavity surface emitting laser comprising:

a substrate on which a pair of mirror portions, an active region, and a tunnel junction are epitaxially grown in a single step in which semiconductor elements are deposited to form a multi-layered structure;

<u>wherein each of the pair of mirror portions includes at least one of the element antimony (Sb) and the compound indium phosphide (InP);</u> and

at least one metal contact disposed on the substrate, wherein electric current is pumped through the pair of mirror portions to electrically pump the active region.

32. The vertical cavity surface emitting laser of claim 21, wherein the substrate includes indium phosphide (InP).

33. The distributed Bragg reflector of claim 32, wherein the plurality of layers are comprised of alternating layer pairs of $Al_aGa_{1-a}As_bSb_{1-b}$ which are approximately lattice-matched to InP, where "a" and "b" indicate relative proportions of the atoms.

34. The distributed Bragg reflector of claim 33, wherein "a" is greater than 0.9 in one layer of the alternating layer pairs and less than 0.9 in another layer of the alternating layer pairs.

35. The distributed Bragg reflector of claim 33, wherein "a" is less than 0.3 in one layer of the alternating layer pairs and greater than 0.3 in another layer of the alternating layer pairs.

36. The distributed Bragg reflector of claim 33, wherein "a" is less than 0.3 in one layer of the alternating layer pairs and greater than 0.9 in another layer of the alternating layer pairs.

37. The distributed Bragg reflector of claim 33, wherein "a" is less than 0.3 in one layer of the alternating layer pairs and "a" is large enough such that the layer is substantially transparent to lasing light.

38. The vertical cavity surface emitting laser of claim 31, wherein the substrate is n-doped with the element selenium (Se).

39. The vertical cavity surface emitting laser of claim 31, wherein the doped tunnel junction is n-doped with silicon (Si).

40. The vertical cavity surface emitting laser of claim 31, wherein the doped tunnel junction is p-doped with CBr4.

41. The vertical cavity surface emitting laser of claim 31, wherein the VCSEL operates in the approximate range from between 1.3 microns and 1.6 microns.

42. The vertical cavity surface emitting laser of claim 31, wherein the pair of mirror portions include a first mirror portion positioned on a top of the active region and a second mirror portion positioned below the active region.

Please add new claims 43-46.

43. (New) A distributed Bragg reflector for use in a vertical cavity surface emitting laser, comprising a plurality of layers of semiconductor material doped to reduce voltage drop and optical loss in a vertical cavity surface emitting laser, the plurality of layers including at least

one layer having the element antimony (Sb) and at least one layer having the compound indium phosphide (InP), wherein the plurality of layers are substantially lattice matched to an InP substrate.

44. (New) The distributed Bragg reflector according to claim 43, wherein the element Sb and the compound InP are included in alternating layers.

45. (New) The vertical cavity surface emitting laser according to claim 17, wherein wherein the element Sb and the compound InP are included in alternating layers.

46. (New) The vertical cavity surface emitting laser according to claim 31, wherein the element Sb and the compound InP are included in alternating layers.

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